

ADDITIONAL FEES:

No additional fees are believed required; however, should it be determined that a fee is due, authorization is hereby given to charge any such fee to our Deposit Account No. 01-0268.

REMARKS

In the last Office Action, claims 1 and 3-7 were rejected under 35 U.S.C. §102(b) as being anticipated by the international journal publication by Wen-Shiung Lour and Chung-Cheng Chang in Solid States Electronics, vol. 39, issue 9, pp. 1295-1298 (1986) ("Wen et al."). Claim 2 was rejected under 35 U.S.C. §103(a) as being unpatentable over Wen et al.

In accordance with the present response, independent claim 1 has been amended to incorporate the subject matter of claim 2 corresponding to the depletion layer being formed in the semiconductor substrate by application of a reverse bias to the photodiode. Independent claim 1 has been further amended to define with more particularity that the depletion layer surrounds the semiconductor layers and has an etched surface portion disposed between the semiconductor layers, which, as further discussed below, is not disclosed or suggested by the prior art of record. Claims 2 and 3 have been amended to conform to the amendments to independent claim

1. A new abstract which more clearly reflects the invention to which the amended claims are directed has been substituted for the previously submitted abstract.

The amendments to the abstract and claims do not raise new issues requiring further consideration and/or search. Instead, independent claim 1 has been amended to incorporate the subject matter of claim 2 corresponding to the formation of the depletion layer and to define with more particularity the etched surface portion of the depletion layer and the structural relation between the depletion layer and the semiconductor layers, claims 2 and 3 have been amended to conform to the amendments to independent claim 1, and a new abstract which more clearly reflects the invention to which the amended claims are directed has been substituted for the previously submitted abstract, thereby placing the application in condition for allowance or in better form for appeal.

Attached hereto is a marked-up version of the changes made to the abstract and claims by the current amendment. The attached pages i-ii are captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE".

Applicant respectfully requests reconsideration of his application in light of the following discussion.

The present invention is directed to a short-wavelength photodiode of enhanced sensitivity with low leak current.

As described in the specification (pgs. 1-3), the detection of light sensitivity in a short wavelength region by conventional photodiodes is inferior. Furthermore, the conventional photodiodes are associated with high leak current.

The present invention overcomes the drawbacks of the conventional art. Fig. 1 shows a photodiode according to the present invention embodied in amended independent claim 1. The photodiode comprises an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal. The optical detection portion has a semiconductor substrate 1 of a first conductive type and semiconductor layers 2a, 2b of a second conductive type formed in spaced-apart relation in a surface of the semiconductor substrate. A depletion layer 3 is formed in the semiconductor substrate 1 by application of a reverse bias to the photodiode so as to surround the semiconductor layers 2a, 2b. An etched surface portion (denoted by X in the copy of Fig. 1 submitted herewith as Exhibit A) of the depletion layer 3 is disposed between the semiconductor layers 2a, 2b.

By the foregoing photodiode construction, the present invention provides a short-wavelength photodiode of enhanced sensitivity and with low leak current. By etching the surface portion of the depletion layer which is disposed between the semiconductor layers, leak current is controlled without greatly influencing the photo sensitivity of the photodiode.

The prior art of record does not disclose or suggest the subject matter recited in amended claims 1-3 and dependent claims 4-7.

Claims 1 and 3-7 were rejected under 35 U.S.C. §102(b) as being anticipated by Wen et al. Applicant respectfully traverses this rejection and submits that amended claims 1 and 3 and dependent claims 4-7 recite subject matter which is not identically disclosed or described in Wen et al.

Amended independent claim 1 is directed to a photodiode and requires an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal, the optical detection portion having a semiconductor substrate of a first conductive type, a plurality of semiconductor layers of a second conductive type formed in spaced-apart relation in a surface of the semiconductor substrate, and a depletion layer formed in the semiconductor substrate by application of a reverse bias to

the photodiode so as to surround the semiconductor layers. Claim 1 further requires that the depletion layer has an etched surface portion disposed between the semiconductor layers.

Wen et al. disclose a PIN photodiode. With reference to Fig. 1 of Wen et al. which has been reproduced herewith as Exhibit B, the PIN photodiode has a p-Si substrate (corresponding to the semiconductor substrate of the claimed invention), an n-type ZnSe layer (corresponding to the semiconductor layers in the claimed invention) formed on the p-Si substrate, an two n+ layers spaced-apart from one another and disposed on the n-type ZnSe layer. The n+ layers are employed as ohmic contacts for the n-type ZnSe layer and an electrode formed on the n+ layers. The n+ layers have an etched surface portion for the purpose of forming an electrode pattern and removing a light obstacle. A depletion layer is formed in the n-type ZnSe layer above the p-Si substrate.

Thus Wen et al. clearly do not disclose or describe a plurality of semiconductor layers formed in spaced-apart relation in a surface of the semiconductor substrate, and a depletion layer surrounding the semiconductor layers and having an etched surface portion disposed between the semiconductor layers, as required by amended independent claim 1. Stated otherwise, the n-type ZnSe layer in Wen et al. does

not comprise a plurality of semiconductor layers formed in spaced-apart relation in a surface of the semiconductor substrate, and a depletion layer surrounding the semiconductor layers, as required by independent claim 10. Furthermore, the depletion layer in Wen et al. does not have an etched surface portion disposed between the semiconductor layers, as required by amended independent claim 1. In this regard, as described above, the etched surface portion in Wen et al. corresponds to the n+ layers, not the depletion layer. The depletion layer in Wen et al. clearly does not have an etched surface portion and, more specifically, an etched surface portion disposed between semiconductor layers formed in spaced-apart relation in a surface of a semiconductor substrate, as required by independent claim 10.

In the absence of the foregoing disclosure recited in amended independent claim 1, anticipation cannot be found. See, e.g., W.L. Gore & Associates v. Garlock, Inc., 220 USPQ 303, 313 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984) ("Anticipation requires the disclosure in a single prior art reference of each element of the claim under consideration"); Continental Can Co. USA v. Monsanto Co., 20 USPQ2d 1746, 1748 (Fed. Cir. 1991) ("When more than one reference is required to establish unpatentability of the claimed invention anticipation under § 102 can not be found."); Lindemann

Maschinenfabrik GmbH v. American Hoist & Derrick Co., 221 USPQ 481, 485 (Fed. Cir. 1984) (emphasis added) ("Anticipation requires the presence in a single prior art reference disclosure of each and every element of the claimed invention, arranged as in the claim").

Stated otherwise, there must be no difference between the claimed invention and the reference disclosure, as viewed by a person of ordinary skill in the field of the invention. This standard is clearly not satisfied by the Wen et al. disclosure for the reasons stated above. Furthermore, Wen et al. do not suggest the claimed subject matter and, therefore, would not have motivated one skilled in the art to modify Wen et al.'s photodiode to arrive at the claimed invention.

Claims 3-7 depend on and contain all of the limitations of amended independent claim 1 and, therefore, distinguish from the reference at least in the same manner as claim 1.

In view of the foregoing, applicant respectfully requests that the rejection of claims 1 and 3-7 under 35 U.S.C. §102(b) as being anticipated by Wen et al. be withdrawn.

Claim 2 was rejected under 35 U.S.C. §103(a) as being unpatentable over Wen et al. Applicant respectfully

traverses this rejection and submits that the teachings of Wen et al. do not disclose or suggest the subject matter recited in claim 2.

Wen et al. do not disclose or suggest the subject matter recited in amended independent claim 1 as set forth above for the rejection of claims 1 and 3-7 under 35 U.S.C. §102(b). Claim 2 depends on and contains all of the limitations of amended independent claim 1 and, therefore, distinguishes from the reference at least in the same manner as claim 1.

In view of the foregoing, applicant respectfully requests that the rejection of claim 2 under 35 U.S.C. §103(a) as being unpatentable over Wen et al. be withdrawn.

The amendments to the abstract and claims do not raise new issues requiring further consideration and/or search. Instead, independent claim 1 has been amended to incorporate the subject matter of claim 2 corresponding to the formation of the depletion layer and to define with more particularity the etched surface portion of the depletion layer and the structural relation between the depletion layer and the semiconductor layers, claims 2 and 3 have been amended to conform to the amendments to independent claim 1, and a new abstract which more clearly reflects the invention to which the amended claims are directed has been substituted for the

previously submitted abstract, thereby placing the application in condition for allowance or in better form for appeal.

In view of the foregoing amendments and discussion, the application is believed to be in allowable form. Accordingly, favorable reconsideration and allowance of the claims are most respectfully requested.

Respectfully submitted,

ADAMS & WILKS
Attorneys for Applicant

By: 

Bruce L. Adams
Reg. No. 25,386

50 Broadway
31st Floor
New York, NY 10004
(212) 809-3700

ABSTRACT OF THE DISCLOSURE

B3

A photodiode comprises an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal. The optical detection portion has a semiconductor substrate of a first conductive type and semiconductor layers of a second conductive type formed in spaced-apart relation in a surface of the semiconductor substrate. A depletion layer is formed in the semiconductor substrate by application of a reverse bias to the photodiode so as to surround the semiconductor layers. An etched surface portion of the depletion layer is disposed between the semiconductor layers.

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE ABSTRACT:

The abstract has been amended as follows:

A photodiode comprises an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal. The optical detection portion has a semiconductor substrate of a first conductive type, [and a] [plurality of] semiconductor layers of a second conductive type formed in spaced-apart relation in a surface of the semiconductor substrate. A depletion layer is formed in the semiconductor substrate by application of a reverse bias to the photodiode so as to surround the semiconductor layers. An [so that an] etched surface portion of the depletion layer [semiconductor substrate] is disposed between the semiconductor layers.

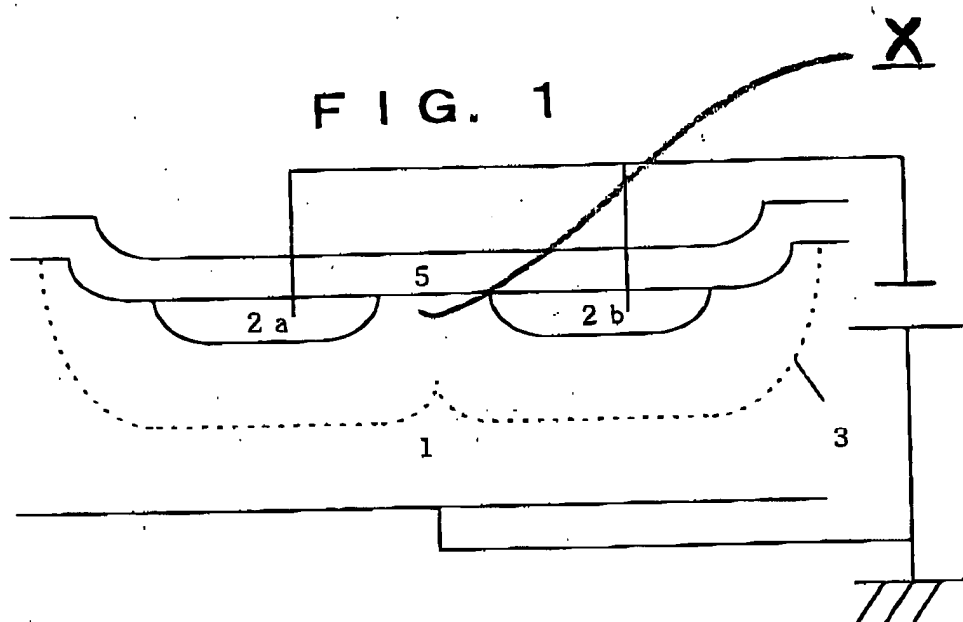
Claims 1-3 have been amended as follows:

1. (Twice Amended) A photodiode comprising: an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal, the optical detection portion having a semiconductor substrate of a first conductive type, [and] a plurality of semiconductor layers of a second conductive type formed in spaced-apart relation in a

surface of the semiconductor substrate, and a depletion layer formed in the semiconductor substrate by application of a reverse bias to the photodiode so as to surround the semiconductor layers, the depletion layer having [so that] an etched surface portion [of the semiconductor substrate is] disposed between the semiconductor layers.

2. (Twice Amended) A photodiode according to claim 1; [further comprising a depletion layer formed in the semiconductor substrate by application of a reverse bias to the photodiode;] wherein a distance between the semiconductor layers is 0.5 to 2 times a width of the depletion layer.

3. (Amended) A photodiode according to claim 1; wherein the etched surface portion of the depletion layer [semiconductor substrate] comprises a wet-etched surface portion.

EXHIBIT AEXHIBIT B